Leveraging Chaos in Continuous Thrust Trajectory Design

Completed Technology Project (2014 - 2018)

Project Introduction

A trajectory design tool is sought to leverage chaos and nonlinear dynamics present in multi-body gravitational fields to design ultra-low energy transfer trajectories, with applications to continuously thrusting spacecraft. Specifically invariant manifolds associated with liberation points will be leveraged in an algorithm to generate initial solutions which will be fed into higher fidelity optimization tools. The tool will be used in a case study to design an interplanetary transfer trajectory for a CubeSat using solar electric propulsion. By combining the inherent efficiency of solar electric propulsion, with the fuel savings available through invariant manifold trajectory design, it is expected the required fuel will be cut significantly, as compared to spacecraft using chemical rockets and Hohmann transfers. The research will contribute to the proliferation of new in-space propulsion systems by providing a simulation-based design tool specifically targeted at such systems. Thus the research answers the call of TABS sections 2.4, In-Space Propulsion Supporting Technology, and 11.18 Simulation Based Systems Engineering. Furthermore, as the algorithm is computationally improved, the trajectory software may be implemented onboard spacecraft, enabling online trajectory design and optimization. Therefore the research meets the call of TABS section 4.5, Autonomy. Finally, ultra-low energy trajectories can be used to cheaply send scouting spacecraft for precursor missions. CubeSat missions, enabled by the proposed research, could serve to study and map human exploration destinations prior to human arrival. Thus the proposed research meets the calls for Destination, Reconnaissance and Mapping, as in section 7.1.1, as well as Modeling, Simulations and Destination Characterization, as in section 7.6.1.

Anticipated Benefits

The research will contribute to the proliferation of new in-space propulsion systems by providing a simulation-based design tool specifically targeted at such systems. Thus the research answers the call of TABS sections 2.4, In-Space Propulsion Supporting Technology, and 11.18 Simulation Based Systems Engineering. Furthermore, as the algorithm is computationally improved, the trajectory software may be implemented onboard spacecraft, enabling online trajectory design and optimization. Therefore the research meets the call of TABS section 4.5, Autonomy. Finally, ultra-low energy trajectories can be used to cheaply send scouting spacecraft for precursor missions. CubeSat missions, enabled by the proposed research, could serve to study and map human exploration destinations prior to human arrival. Thus the proposed research meets the calls for Destination, Reconnaissance and Mapping, as in section 7.1.1, as well as Modeling, Simulations and Destination Characterization, as in section 7.6.1.

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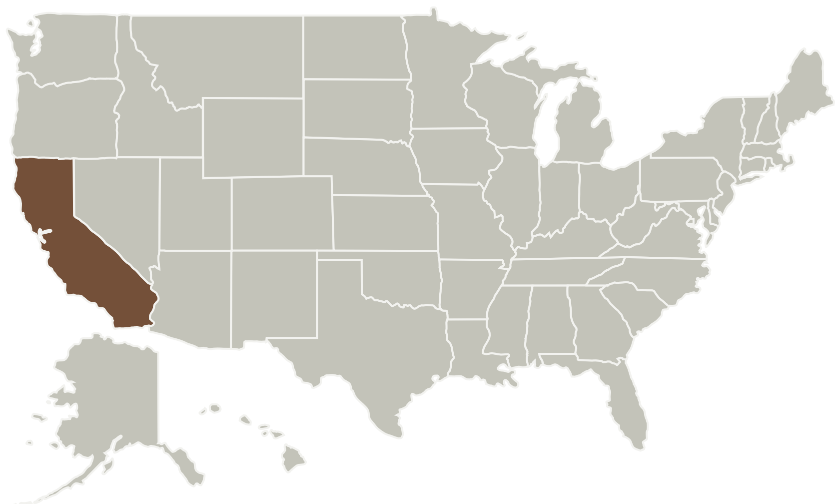
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Stanford University(Stanford)	Lead Organization	Academia	Stanford, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Stanford University (Stanford)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

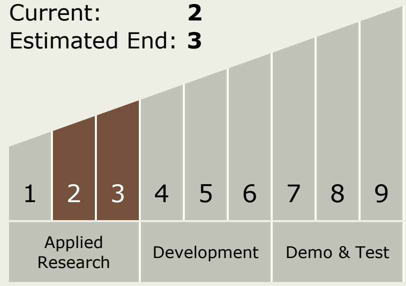
Sigrid Close

Co-Investigator:

Travis Swenson

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.2 Navigation Technologies
    └ TX17.2.6 Rendezvous, Proximity Operations, and Capture Trajectory Design and Orbit Determination

Target Destination

Foundational Knowledge